FLINN FAX!
FLINN SCIENTIFIC INC.
"Your Safer Source for Science Supplies"
Vol. 09-1 | Chemistry Edition

Alka-Seltzer® and Gas Solubility

Students Compare the Effects of Temperature

Introduction

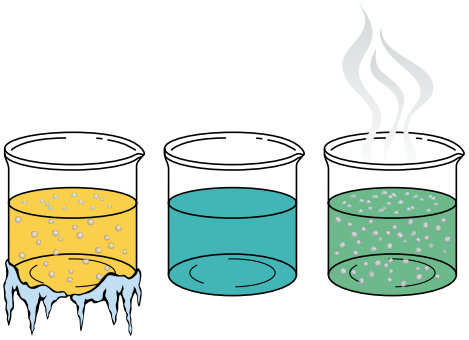
The solubility of solids and liquids generally increases as the temperature increases. In the case of gases, however, this generalization is always wrong! What can Alka-Seltzer teach us about the effect of temperature on the solubility of a gas?

Concepts

- Gas solubility
- Reversible reactions

Safety Precautions

Sodium hydroxide solution is a corrosive liquid. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please consult current Material Safety Data Sheets for additional safety information.



Materials

Alka-Seltzer tablet
Bromthymol blue indicator, 0.04%, 10 mL
Sodium hydroxide solution, 1 M, NaOH, 5 mL
Tap water
Ice bath
Balance
Beakers, 250-mL, 3
Beral-type pipets, thin-stem, 2
Graduated cylinders, 10- and 25-mL
Hot plate
Stirring rod
Test tube rack
Test tubes, 25 × 150 mm, 3
Thermometer
Weighing paper or weighing dishes, 2

Procedure

1. Add 200 mL of water to each of three 250-mL beakers. Place one beaker in an ice bath, heat the second beaker on a hot plate, and allow the third beaker to equilibrate at room temperature.
2. Obtain two 1.0-g samples of Alka-Seltzer tablets in a weighing dish.
3. When the water on the hot plate has reached a temperature of 75–80 °C, remove it from the heat. Remove

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Greening the School Science Lab

Improve Safety and Reduce Waste

Introduction

For almost 30 years, Flinn Scientific has embraced a consistent philosophy regarding the use of chemicals in school science labs: "Chemicals in any form can be safely stored, handled or used if the physical, chemical, and hazardous properties are fully understood and the necessary precautions, including the use of proper safeguards and personal protective equipment, are observed." We still believe this philosophy is appropriate.

Nevertheless, the list of banned or restricted lab chemicals in various states continues to grow. In July 2008, Illinois joined at least seven states that have banned mercury, even in thermometers. With so much negative attention focused on "problem" chemicals, the idea of "green chemistry" may seem like an oxymoron. Green chemistry is a real program with a positive message about chemistry and science. The *Green Chemistry Program* was initiated by the U.S. Environmental Protection Agency in the 1990s with the goal of applying chemical principles to prevent pollution. The program calls for the design of chemical products and processes that will reduce the use and generation of hazardous substances. How can individual teachers and schools benefit from the principles of green chemistry?

Basic Principles of Green Chemistry

Green chemistry presents a wonderful opportunity for science teachers to increase safety, improve science edu-

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What's Inside

Greening the School Science Lab—Continued from page 1

cation, and impart the values and benefits of science to the next generation. The basic principles of green chemistry as they relate to school science labs include:

- Design lab activities to avoid generating hazardous by-products that require waste disposal.
- Substitute less hazardous and less toxic chemicals in chemical reactions or lab tests.
- Perform lab activities on a small-scale or microscale level to reduce the amounts of chemicals used.
- Use catalysts to avoid by-product formation in chemical reactions.
- Avoid high temperature or high pressure conditions for chemical reactions.

Reviewing Lab Activities

To implement green chemistry, science teachers need to know what chemicals are being used in lab activities. This requires two things—an accurate inventory of chemicals, and a list of chemicals used in experiments and demonstrations in science courses. After compiling the list of chemicals they actually use, most departments find that half of the chemicals in their inventory are not needed! In reviewing current lab activities, carefully compare the hazards of chemicals versus the learning goals. Many science departments use lead nitrate, for example, to demonstrate crystal formation for lead iodide. It is a beautiful demonstration! Is the need for licensed hazardous waste disposal of the heavy metals used in this demonstration justified in terms of the learning goals? Mixing copper chloride and sodium phosphate solutions gives a pretty turquoise solid. It teaches the same thing, and it is "greener" and safer.

Advantages of Microscale Labs

The advantages of microscale lab activities are well known—the labs are faster, students and teachers are exposed to lower concentrations of possibly hazardous chemicals, departments save money in the cost of chemicals, glassware, and equipment, teachers spend less time setting up and cleaning up, and the amount of waste generated is greatly reduced. Many common lab activities can be microscaled simply by combining drops of liquids in a well plate instead of mixing liquids in a beaker.

Color the Curriculum Green!

- Incorporate waste treatment into lab procedures—neutralize acids, reduce halogens, precipitate silver ions.
- Purchase digital thermometers—they are safer and more precise.
- Use lower concentrations and less hazardous forms of chemicals.
  - –Always work with the lowest concentrations possible of strong acids.
  - –Substitute solutions for pure solids. The LD_{50} of copper(II) chloride is 140 mg/kg—extremely toxic. Using 1 M $CuCl_2$ solution reduces the hazard almost tenfold!
  - –Use ethyl alcohol instead of methyl alcohol wherever possible.
  - –Avoid finely divided metals. Granular zinc is safer than zinc dust; magnesium ribbon is safer than magnesium powder.
  - –Ammonium chloride is less hazardous than ammonium nitrate.
- Perform a modern variation of the classic Boyle's law experiment using a pressurized soda bottle rather than a mercury-filled column.
- To determine the molar volume of a gas, generate hydrogen gas instead of oxygen, which requires dangerous potassium chlorate.
- Use sodium hypochlorite rather than sodium dichromate as an oxidizing agent.
- Substitute a propylene glycol–based preservative such as Formalternate® for formaldehyde in dissection activities.
- Use iron instead of nickel or cobalt salts to study coordination compounds.
- Incorporate applications-oriented experiments wherever possible: acid–base titrations of fruit juices, redox reactions using Vitamin C, paper chromatography of amino acids, etc.
- Teach fundamental principles in environmental science. Determine the alkalinity or buffer capacity of water by acid–base titration; use the Winkler method to measure dissolved oxygen in water; simulate the production and properties of acid rain; investigate the specific heat values of sand, soil, and water.

Green chemistry does NOT mean doing fewer labs, "dumbing down" the curriculum, or teaching less science. By practicing green chemistry, you will be able to teach the same concepts and accomplish the same learning goals. More importantly, you will be making a positive contribution to the environment and to science education by empowering and exciting the next generation of scientists.

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See pages 12–39 in the *2009 Flinn Catalog/Reference Manual.*

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Alka-Seltzer and Gas Solubility—Continued from page 1

the cold water beaker from the ice bath at this time also.

4. Add 3 mL of bromthymol blue to each beaker. (The water should be blue-green, indicating a neutral pH.)
5. Simultaneously drop the two Alka-Seltzer samples into the hot and cold beakers. Observe and compare evidence of physical and chemical changes in each beaker. (The Alka-Seltzer will dissolve and effervesce, producing carbon dioxide gas. The reaction occurs significantly faster in hot water than in cold water. The cold water reaction takes about 5 minutes, while the hot water reaction appears to be complete in about 30 seconds.)
6. When the Alka-Seltzer tablets have fully dissolved, note the color and appearance of the solution in each beaker. (The cold water mixture is yellow; the hot water mixture is green.)
7. Measure the temperature of each solution, including the room temperature control, and label three large test tubes with the corresponding temperature.
8. Using a graduated cylinder, remove a 25-mL sample from each beaker, including the room temperature control, and place the sample in the appropriately labeled test tube.
9. Using a thin stem pipet, add 1 M sodium hydroxide solution dropwise to the cold water mixture. Count the number of drops of NaOH that must be added to match the color of the room temperature control solution. Stir or swirl between drops to ensure thorough mixing. (For the mixture at 5 °C, six drops of NaOH are required to neutralize the excess dissolved carbon dioxide.)
10. Repeat step 9 using the hot water mixture, again comparing the color with that of the room temperature control. (Only one drop of NaOH is required.)

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures. The solutions may be rinsed down the drain with excess water according to Flinn Suggested Disposal Method #26b.

Tips

- Bromthymol blue is yellow when the pH is less than 6.0, blue when the pH is greater than 7.6, and various shades of green when the pH is between 6.0 and 7.6. Check the color of the tap water in each beaker before adding Alka-Seltzer in step 2. If the water is not blue or blue-green, add one drop of sodium hydroxide solution to each beaker.
- Other indicators that may be used in this demonstration include phenol red and neutral red.
- Tap water is preferred over distilled or deionized water in this demonstration. Distilled or deionized water acts like a sponge in absorbing carbon dioxide from the air!

Discussion

Alka-Seltzer contains aspirin, sodium bicarbonate, and citric acid. The active antacid or buffering ingredients are sodium bicarbonate, a weak base, and citric acid, a weak acid. When the tablet dissolves in water, one mole of citric acid reacts with three moles of bicarbonate ion. The products of the neutralization reaction are citrate ion, carbon dioxide and water (Equation 1). The citrate ion acts as a buffer against "excess stomach acid."

$$H_3C_6H_5O_7(aq) + 3HCO_3^-(aq) \rightarrow C_6H_5O_7^{3-}(aq) + 3CO_2(g) + 3H_2O(l)$$

Equation 1

When carbon dioxide dissolves in water (Equation 2), it combines reversibly with water to form carbonic acid (Equation 3), which behaves as a weak acid (Equation 4).

$$CO_2(g) \leftrightarrows CO_2(aq)$$

Equation 2

$$CO_2(aq) + H_2O(l) \leftrightarrows H_2CO_3(aq)$$

Equation 3

$$H_2CO_3(aq) + H_2O(l) \leftrightarrows HCO_3^-(aq) + H_3O^+(aq)$$

Equation 4

All three reactions are reversible. In the case of Equations 3 and 4, the equilibria for these reactions strongly favor reactants. The overall result, however, is that carbon dioxide dissolves in water to give a weakly acidic solution (pH 3–5), and the acidity of the solution depends on the amount of dissolved carbon dioxide. Any factor that influences the solubility of carbon dioxide gas in water will also affect the pH of the solution and the total amount of acid present. In this demonstration, the effect of temperature on the solubility of carbon dioxide can be followed by observing both the indicator color changes and the "neutralization equivalent" of the solution (number of drops of NaOH required to neutralize a given volume of solution). The cold Alka-Seltzer solution is yellow (pH < 6.0) and requires six drops of NaOH per 25 mL of solution. The hot Alka-Seltzer solution is green (pH = ca. 6.8) and requires only one drop of NaOH per 25 mL of solution. The solubility of carbon dioxide decreases as the temperature increases.

The effect of temperature on gas solubility has important implications for the environment. Thermal pollution of lakes and streams occurs when power plants discharge cooling water back into the natural water source at a higher temperature than it was originally. The reduced oxygen availability coupled with increased biological oxygen demand at higher temperatures affects the number and type of organisms in the water

Materials for *Alka-Seltzer and Gas Solubility* are available from Flinn Scientific

Catalog No.	Description	Price/Each
B0173	Bromthymol Blue Indicator Solution, 0.04%,100 mL	**$3.00**
S0148	Sodium Hydroxide Solution, 1 M, 500 mL	**6.00**

Solutions and Solubility

View Another Gas Solubility Demo

Flinn's new *Teaching Chemistry—eLearning Video Series* includes another demo entitled "Solubility of Gases" to teach this same concept.

See page 27 in the *2009 Flinn Scientific Catalog/Reference Manual,* then go to www.flinnsci.com and click on the **e**Learning button. "Solubility of Gases" is part of the *Saturated, Unsaturated, and Supersaturated Solutions* video package.

Rainbow Reaction

Colorful Acid–Base Demonstration

Introduction

Saturated sodium carbonate solution is added to a test tube containing a dilute solution of hydrochloric acid and universal indicator. A rainbow column of colors develops in the tube as the dense sodium carbonate solution sinks to the bottom and carbonate ions gradually diffuse upward and neutralize the hydrochloric acid solution.

Concepts

- Acids and bases
- pH
- Indicators
- Neutralization

Materials

Hydrochloric acid, HCl, 0.1 M, 20 mL
Sodium carbonate solution, Na_2CO_3, saturated, 6 mL
Universal indicator, 3 mL
Pipets, Beral-type, 2
Test tube, large, 20 × 150 mm
Test tube rack

Safety Precautions

Dilute hydrochloric acid and saturated sodium carbonate solutions are skin and eye irritants. Avoid contact of all chemicals with eyes and skin. Universal indicator is an alcohol-based solution and is flammable. Keep away from flames and other ignition sources. Wear chemical splash goggles and chemical-resistant gloves and apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

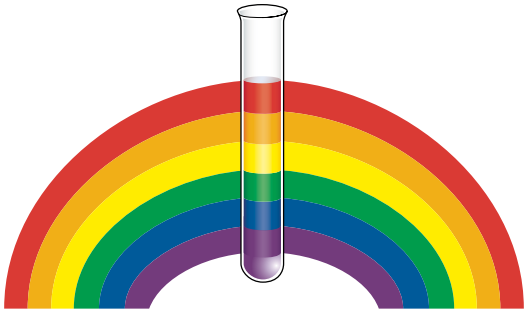
1. Add about 3 mL of universal indicator, followed by 20 mL of hydrochloric acid solution, to a large test tube. Swirl the test tube to mix.
2. Fill a Beral-type pipet with saturated sodium carbonate solution.
3. Tilt the test tube slightly and slowly squeeze the saturated sodium carbonate solution down the side of the test tube. Do not attempt to layer the solutions. The sodium carbonate solution will sink to the bottom of the test tube.
4. Refill the Beral-type pipet with a second portion of saturated sodium carbonate and add it to the test tube well.
5. Set the test tube in a test tube rack. Colored layers form immediately as carbonate ions diffuse upward and react with hydrogen ions in the acidic solution.
6. Observe the gradual appearance of a rainbow spectrum of colored layers in the tube. Relate the colors to the reactions taking place in the test tube and the resulting pH changes.

Disposal

The rainbow tube contents may be washed down the drain with plenty of excess water according to Flinn Suggested Disposal Method #26b. Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste.

Tips

- The rainbow column of colors will last for a week or more if the test tube is left undisturbed.



- Colored layers develop in the test tube in the following order, from top to bottom: red, orange, yellow, green, blue, and purple. Discuss the order of colors within the test tube and their significance.

Discussion

The initial hydrochloric acid solution has a pH of about 1 and turns red with universal indicator. Saturated sodium carbonate contains more than 20 grams of solute per 100 mL of solution and has a density of 1.1–1.2 g/mL. The dense sodium carbonate solution immediately settles to the bottom of the test tube. The sodium carbonate solution has a pH of about 12 and turns purple with universal indicator.

Carbonate and sodium ions diffuse upward through the solution to balance the concentration gradient in the test tube. In the process, a neutralization reaction takes place between carbonate ions and hydrogen ions in solution and different colored layers develop at various depths in the test tube. The colors of the layers reflect different hydrogen ion concentrations as the diffusion and neutralization processes balance each other out. The balanced net ionic equations for the neutralization reactions between sodium carbonate and hydrochloric acid are as follows:

$$H^+(aq) + CO_3^{2-}(aq) \rightarrow HCO_3^-(aq)$$
$$H^+(aq) + HCO_3^-(aq) \rightarrow H_2CO_3(aq)$$
$$H_2CO_3(aq) \rightarrow H_2O(l) + CO_2(g)$$

Materials for *Rainbow Reaction* are available from Flinn Scientific

Catalog No.	Description	Price/Each
H0014	Hydrochloric Acid Solution, 0.1 M, 500 mL	$5.95
S0052	Sodium Carbonate, 500 g	5.65
U0001	Universal Indicator Solution, 100 mL	7.75

More Acid–Base Demos

Flinn's new *Teaching Chemistry—eLearning Video Series* offers more than 20 proven demonstrations and activities to help you teach acid–base chemistry. Videos and printable support materials from award-winning chemistry teachers are available 24/7. See page 3 in this Flinn Fax to learn more about Flinn's *Teaching Chemistry—eLearning Video Series*.

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Resolution: 0.1 °C / 0.2 °F
Accuracy: ±1 °C / ±2 °F

Catalog No.	Description	Price/Each
AP6049	Flinn Digital Pocket Thermometer	**$19.95**
AP8716	Flinn Digital Thermometer	**25.85**

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Catalog No.	Description	Price/Each
SE3006	Fire Blanket with Case	**$106.00**
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Catalog No.	Description	Price/Each
AP7285	Solids and Liquids— Activity-Stations Laboratory Kit	**$59.25**

Fluorescent Oscillating Reaction

Green to Orange Again and Again

Eerie and incredibly cool! Mix colorless and dark green solutions in a beaker and start stirring. The color of the solution changes to orange and then green. Dim the lights, however, switch on a black light and the real show begins! Observe the brilliant, fluorescent orange glow! This unique adaptation of a classic oscillating reaction is due to rising and falling concentrations of ruthenium(II) and (III) complex ions. Use the beautiful, radiant color changes to illustrate oxidation states, then sit back and enjoy the show! This is a "must do demo" if your school colors are green and orange.

Note: A UV lamp or other black light source is needed to view the fluorescence and may be purchased separately.

Catalog No.	Description	Price/Each
AP7245	Fluorescent Oscillating Reaction	**$59.95**
AP9030	Ultraviolet Lamp, 18"	**35.50**

Learn 4 More Fluorescence Demonstrations

View *Let There Be Light* in Flinn's new *Teaching Chemistry—eLearning Video Series* at www.flinnsci.com

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Catalog No.	Description	Price/Each	Price/Each Qty. 72–299	Price/Each Qty. 300 or more
AP3306	Standard Vented Goggles	**$6.65**	**$6.25**	**$5.30**
AP3309	Standard Vented Goggles with fog-free lens	**7.85**	**7.45**	**7.05**
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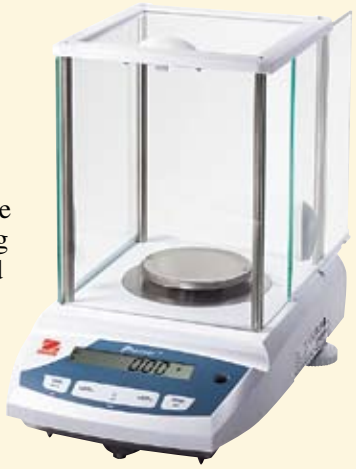
Pioneer Analytical Balance



Here's an analytical balance with a readability of 0.0001 g designed for uncomplicated performance. All operations are easy, thanks to the three-button touch control, large weighing chamber, and simple calibration procedure. The draft shield and load cell produce stable weighing results. Large LCD display. This balance is the perfect choice if you teach AP chemistry or use microscale techniques. Catalog No. OB2102.

Catalog No.	OB1054	OB2102
Readability (g)	0.1	0.0001
Capacity (g)	400	65
Price/Each	**$178.00**	**$1697.00**

See more Ohaus Scout *Pro* Balances and Pioneer Analytical Balances and accessories on pages 187–188 of the *2009 Flinn Scientific Catalog/Reference Manual*.

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NEW SEE PAGE 3

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Safe Use, Handling, Storage, and Disposal of Laboratory Chemicals
Thursday, March 19, 1:30 PM – 3:00 PM

Morning of Chemistry
Friday, March 20, 10:00 AM – 11:30 AM

Teaching Chemistry—eLearning Video Series
Friday, March 20, 12:30 PM – 1:30 PM

Additional Flinn workshops include: AP Chemistry, *Flinn ChemTopic™ Labs,* Inquiry-Based Demonstrations, Biotechnology and Genetics Activities, Laboratory Design and more! Visit the Flinn booth or check your conference program for times and locations.

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